NJ TRANSIT
RAIL OPERATIONS

ASES

Advanced Speed Enforcement System

Technical Tutorial-March 2001

February 9, 1996

GOAL: Enhance Safety

- Eliminate human error by stopping train before stop required
- Provide as soon as possible
- Use proven technology

Automatic Train Control (ATC)

- On 36% of NJ TRANSIT system in 1996.
- A continuous system which provides cab signals to the train engineer with automatic speed enforcement.
- Uses rails as transmission medium.

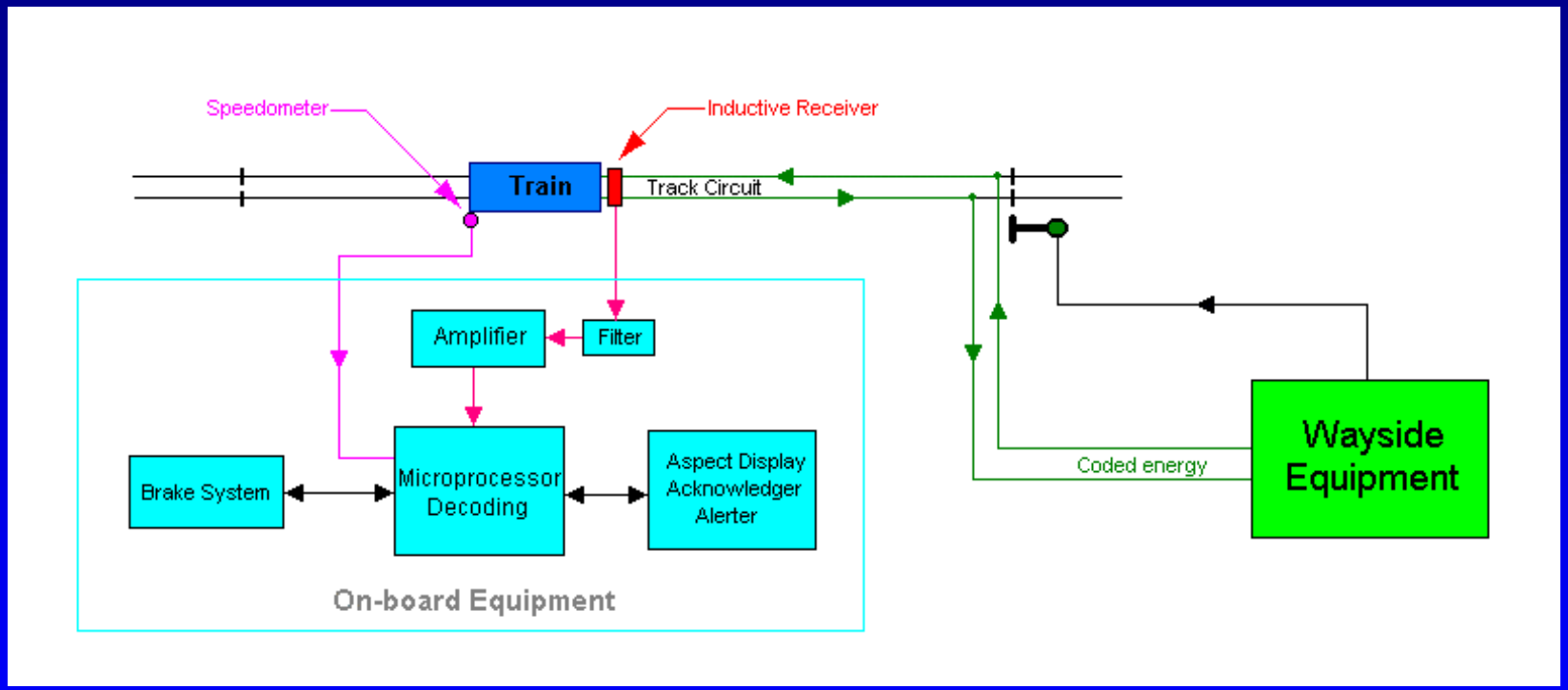
ATC Positive Features

- Provides continuous in-cab signal aspects.
- Provides detection of changed signal and misaligned switch, broken rail, or other obstruction after passing wayside signal.
- Ensures response to signal downgrade.
- Required for operation on AMTRAK NEC.

ATC Negative Features

- Restricted speed does not ensure a stop before a stop signal.
- Not practical for civil speed restrictions (only a limited number of speed codes available).
- Cannot be used for temporary speed restrictions.

ATC Functional Diagram



Speed Enforcement System (SES)

- An *intermittent* transponder-based system which has the capability for cab signals, automatic speed control, and Positive Train Stop.
- Transponders at wayside signal locations programmed with fixed & variable (aspect/route) information.
- Trains automatically know location & braking profile.

SES Positive Features

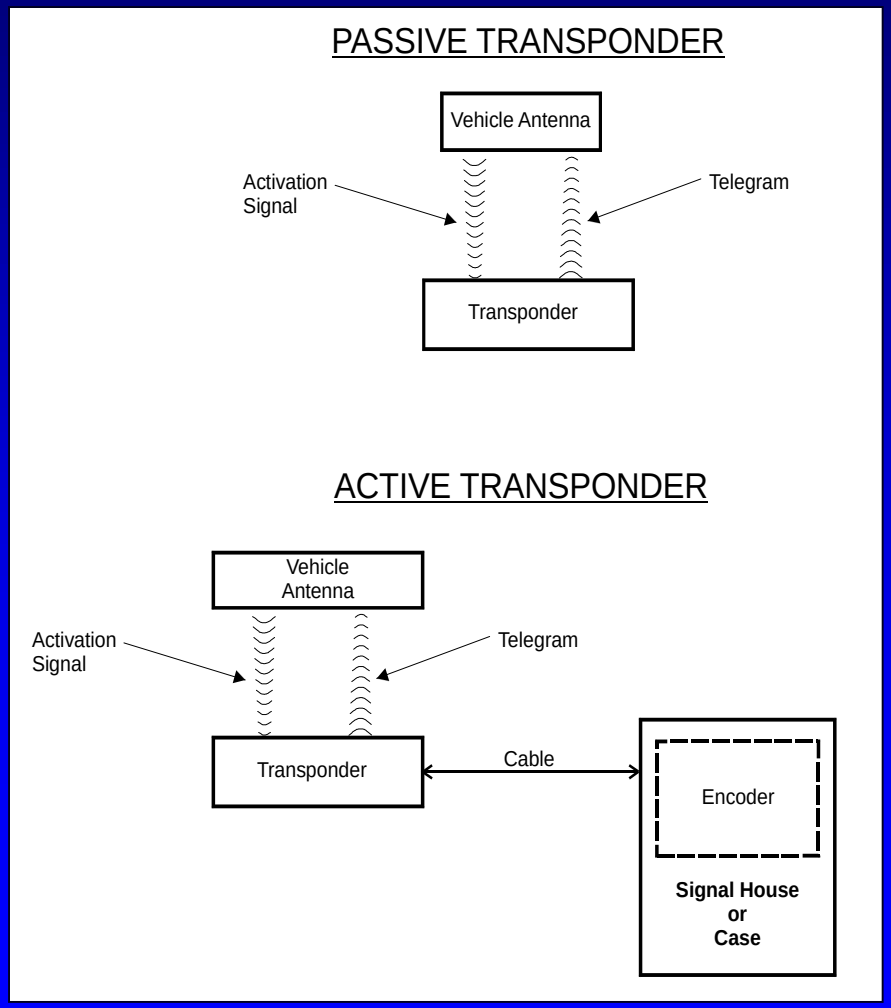
- Can stop a train prior to passing a stop signal.
- Can be used for temporary speed restrictions.
- Can be used for civil speed restrictions.
- System has 20 years history in Europe.

SES Negative Features

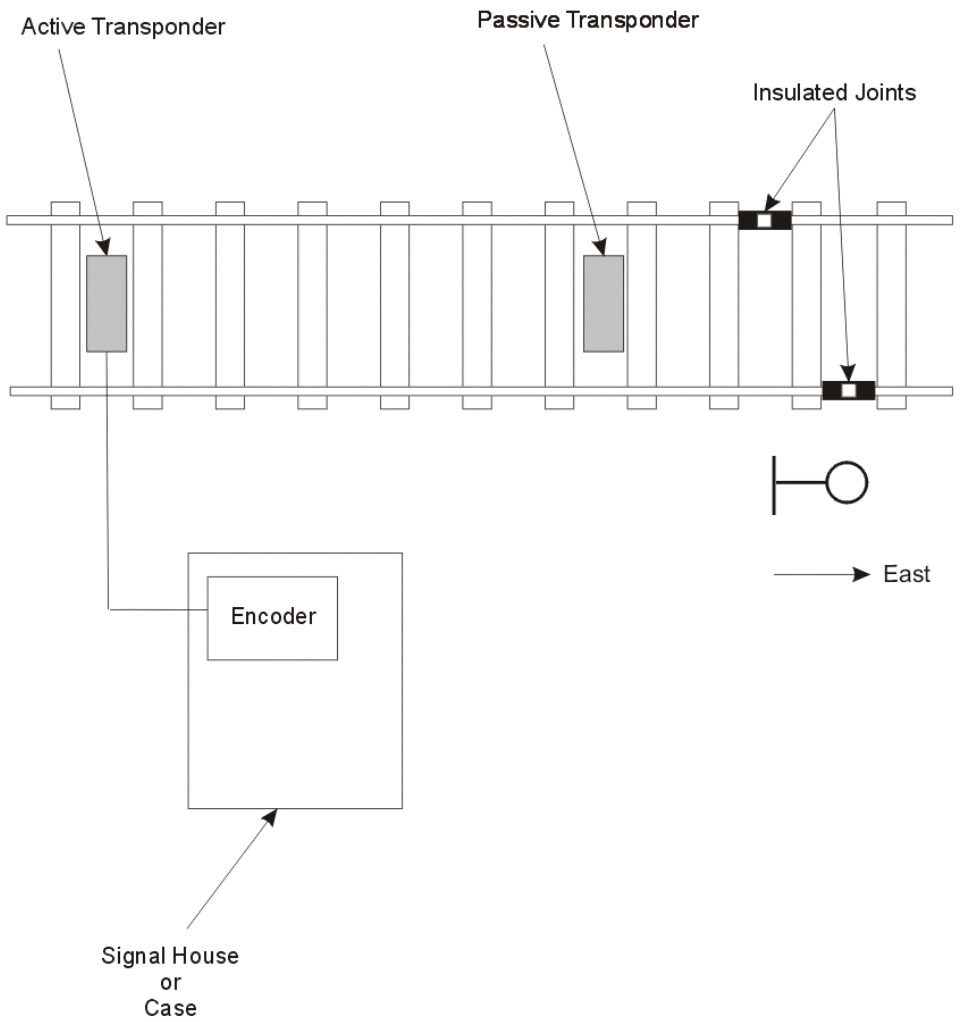
Between transponders:

- Cannot detect a broken rail.
- Cannot detect a misaligned switch.
- Cannot indicate an upgrade or downgrade of a signal.

SES Data Uploading Diagram



Transponder Group



Transponder Types

- Passive transponder
  - a stand-alone device
  - always transmits its *resident* telegram to train
- Active transponder
  - Connected to an encoder that supplies telegrams that correspond to different input conditions (signal aspects)
  - Contains a resident, or default, telegram transmitted if the encoder or associated component, such as the connecting cable, fails.

Transponder Data

- Transponder positioning & linking
- Configuration of transponder group
- Territory
- LoA (signal aspect & type, gradient, target speed & type, distance to target & increase, route)
- Civil restrictions
- Installation area identification

Transponder Operation

- On-board antenna generates 27 MHz field
  - Induces current in transponder to power electronics
  - AM supplies 50K b/s clock signal
- Data bits clocked from memory to form telegram
- Each “1” bit pulses a resonant uplink antenna circuit that generates 4.5 MHz signal

Transponder Telegram

- Telegram format: 255 bits in BCH code
  - 180 user bits
  - 64 bits BCH CRC
  - 8 bits for synchronization
  - 1 bit for inversion protection
  - 2 bits to give CRC a mix of 1s & 0s
- Code is cyclical
  - any 255 bits can be checked
  - No waiting for verification, only data

Transponder Bit Assignments

- Coordinated with Alstom for ACSES
- Preserve future undefined functionality
- Allow distinguishing among train types
- Unique identification of location
- Duplication within group of certain information
- Up to 4 transponders in group

ASES

- Combines “proven” ATC and SES.
- Can be incrementally installed-builds on existing wayside investment.
- Gives maximum safety benefits.
- Needs no satellite or radio infrastructure or on-board database.
- Has *not* been done before.

ASES Functionality

- Replace existing on-board ATC.
- Function as system speedometer.
- Efficiently display speed authorities (SDU).
- Provide speed authority enforcement
  - Positive stop-signal
  - civil (fixed)
  - signal (variable)
  - temporary restrictions
- Recurring acknowledge (55-sec./restricting)

ASES Functionality (cont'd)

- Automatic freight/passenger characteristics.
- Roll-away protection.
- Automatic self-test.
- Solid-state/microprocessor reliability.
- Software-based; allows for future functionality.
- Minimal additional wayside infrastructure.
- Integrated FRA/System event recorder.

ASES Functionality (cont'd)

- Seamlessly operates over various territories.
  - Non-equipped
  - Cab signal/ATC only (includes 9-aspect HDIS)
  - SES-only (existing wayside signal overlay) and against the current of traffic in NORAC rule 251 ABS.
  - Combined ASES
  - AMTRAK ACSES
  - "Unknown"
  - Installation area

Territories

- Unknown: provides control at start up (cab keyed on), power reset, and predefined system exit areas; enforces a 10 mph speed limit
- Non-equipped: supervises 79 MPH MAS
- Cab signal: Enforces speed limits associated with 9 valid 100/250 Hz codes transmitted through rails
- SES-only: enforces wayside signal, civil restrictions, and territory type status from active & passive transponders at all signal locations

Territories (cont'd)

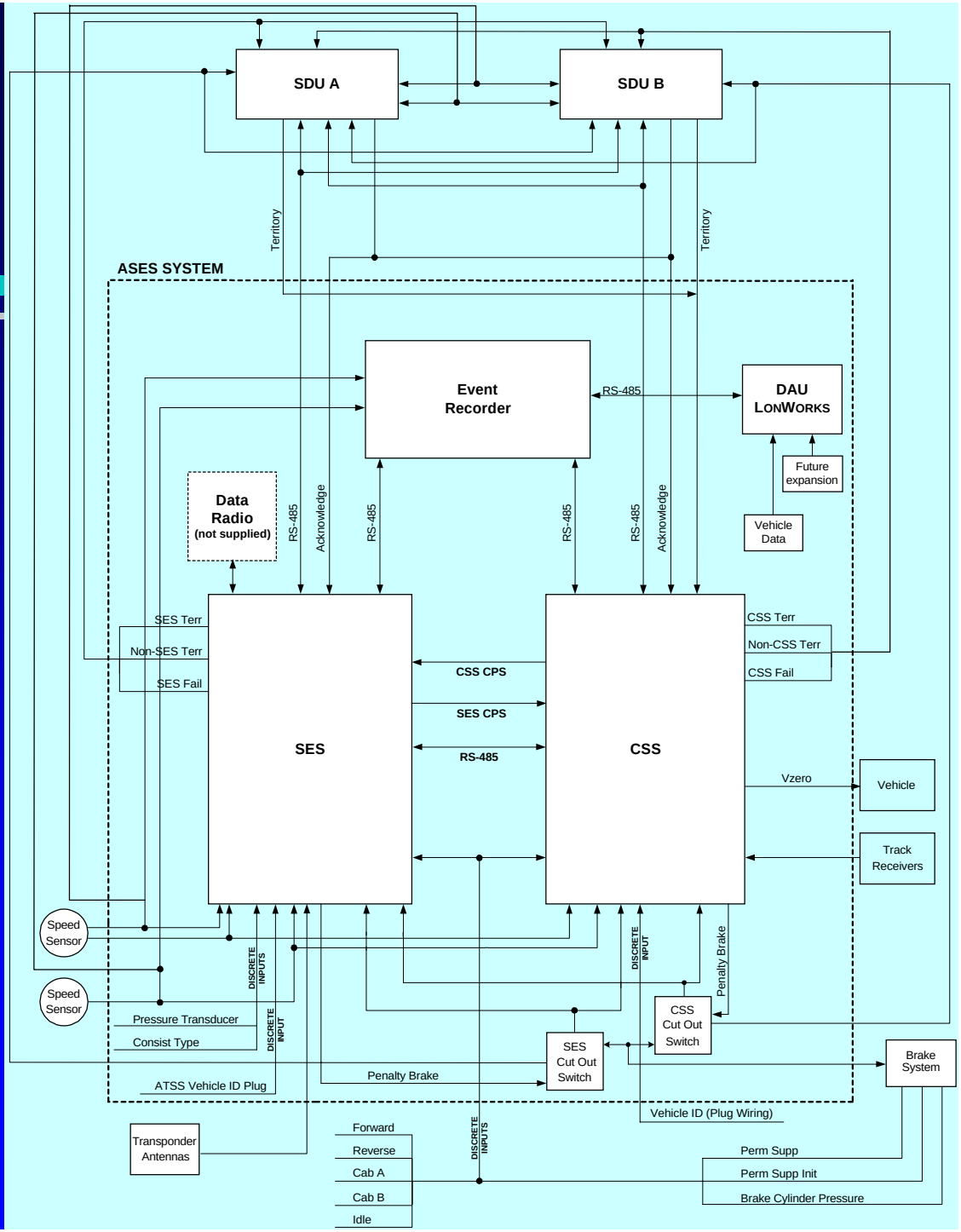
- Combined: active transponders at distant and home signals; passive transponders at all signal locations provide positioning information for distance tracking, fixed civil restrictions, and territory type data. Cab signal code inputs used in conjunction with transponder information to provide *continuous* speed enforcement.
- Installation Area: defined speed enforced within a defined maximum distance. All other information ignored (Cab & SES). Avoids need to cut system out during construction.

ASES Functionality Issues

- Complete definition of cab signal code rates
  - Mid-block up/down grades
  - Correspondence at wayside signals
- Interpretation of all Signal Aspect Rules
- Territory Boundary Conditions
- Formal FMECA
- Recorder & Playback Software
- Unique “Pass Stop” Codes

On-board System

Block Diagram



ASES Implementation

- Vehicle installation off-site
- Functional testing/calibration
- New operating rules required
- System familiarization:
  - Test trains
  - SDU
  - Train crews require hands-on training
  - Field forces require installation/troubleshooting training
- Wayside installation in stages
- Temporary freight train operational waiver
- Software versions (ACSES volatility)

Originally Proposed Schedule

- Eighteen months from NTP: train control using either ATC or SES on entire NJ TRANSIT system.
- Sixty months from NTP: ASES on all NJ TRANSIT lines.

ASES Delay Issues

- FCC license (Temporary, Petition for Permanent new rules with HSRC, Retest & Resubmit)
- Integration of SES with ATC
  - Limited on-board “real estate”
  - Additional functionality for operation in *all* territories
  - Modeling
  - New Hardware & Software Simulator
- New Graphical SDU flat panel display
- Precision of ROW information
- AMTRAK ACSES Compatibility
- Software & Hardware Verification and Validation
- FRA recorder integration
- Custom requirements of individual vehicles (vs. trains)

Current Schedule

- 24 months from NTP: Train control using either ATC or SES on all NJ TRANSIT lines.
- 72 months from NTP: ASES on all NJ TRANSIT lines.

CURRENT Contract Plan

- Phase I – Demo
- Phase II –
  - Install SES only on Pascack Valley Line
  - Install ASES on trains for NEC HDIS operation
- Phase III – Install ASES on remainder of system

Phase I-Demo

- **Location:** Between Boonton & Dover
- **Vehicles:** 5 Planned; 4 Actual:

  Diesel Locomotive & Cab Car, Married-Pair MU; No Single MU; future Electric Locomotive (only EMI test)
- **Schedule:** Planned: 6 mos.; Actual: 18-36 mos.

Phase II

- **Location:** Planned: Pascack Valley, Main, & Boonton Lines (115/72 Miles); Actual: Pascack Valley Line (23 Track/Route Miles)
- **Vehicles:** One hundred nine (109)
- **Schedule:** Planned: 12 mos from demo (~June 1999); Current: Pascack Valley Spring 2001; Vehicles prior to HDIS Startup on NEC (10/01)


NJ TRANSIT
Passenger Rail System
February 2001
ASES PROJECT
Not to scale
Newark City Subway
Legend
MAIN LINE
PASCACK VALLEY LINE
BERGEN LINE
BOONTON LINE
MONTCLAIR BRANCH [M&E]
MORRISTOWN LINE [M&E]
GLADSTONE BRANCH [M&E]
RARITAN VALLEY LINE
NORTHEAST CORRIDOR
NORTH JERSEY COAST LINE
ATLANTIC CITY LINE
HBLRT
NY
NJ
PA
Midtown Direct
Waterfront Connection
New York Penn Station
Hoboken
Newark (Broad St)
Philadelphia 30 St Station
Philadelphia International Airport
Atlantic City

March 2001

Revised ATC Installation

- In-house design & installation of Standard 4-aspect
- M&E, Bergen, Boonton, Main, & Raritan Valley Lines
- 282 Track/167 Route Miles Added since ‘96
  - 441 (or 82% of the total signaled) track miles now equipped for ATC.
  - entire 214 mile Newark Division is completed
  - 227 (or 71%) of Hoboken track miles equipped
- Complete in 2002, Design & installation underway
- Progress as of March 2001: 87%

ATC Wayside Design & Installation

- All 6,000 circuit drawings for 255 locations on M&E existed only on mylar film
  - mylars raster scanned and attached to a CADD design file
  - produced over 200,000 individual sheets of drawings

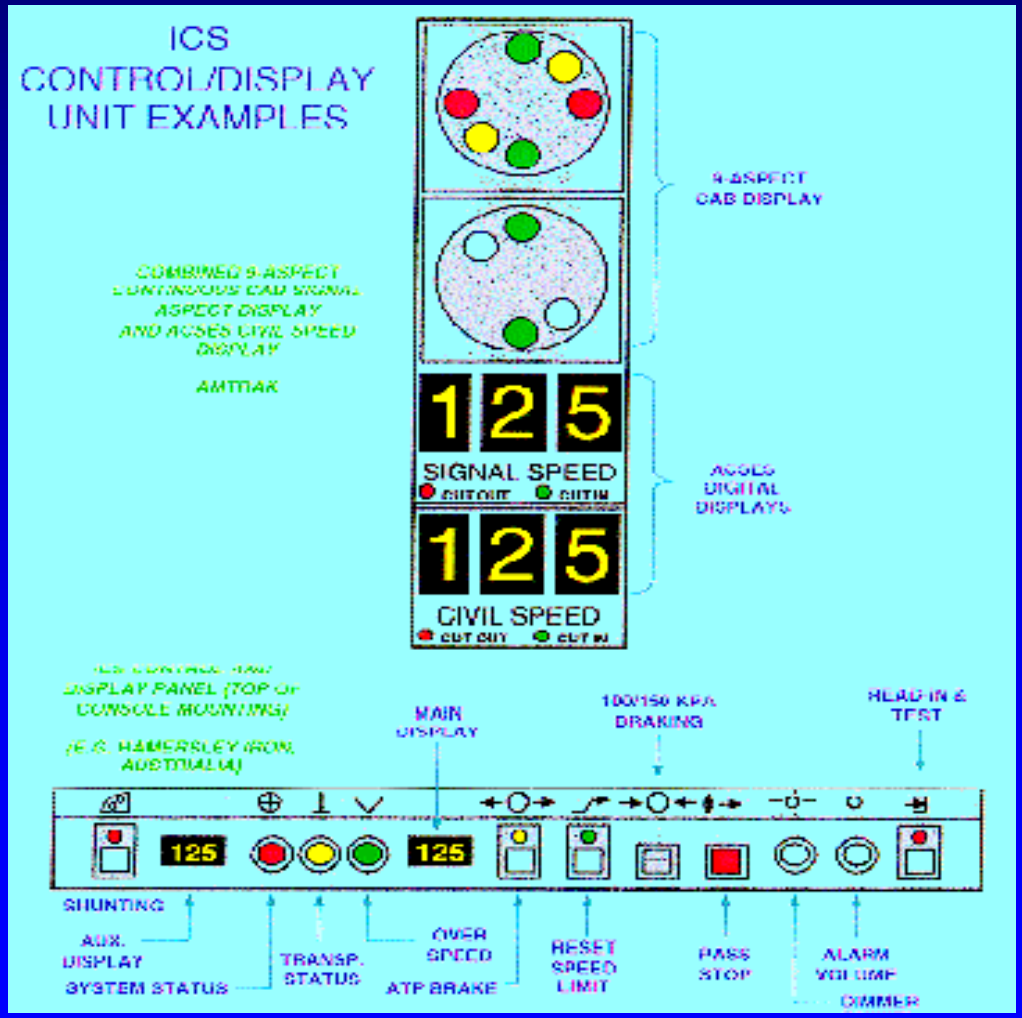
ATC Wayside Design & Installation

- 12 interlockings
  - all track circuits replaced
  - "portable" track circuit while permanent changes made
  - more than 100 track circuits under traffic, each with 12 hand-wired components
- ATC circuitry had more than 100,000 wire changes
  - Teflon-based wire insulation
  - approach-lit the wayside signals
  - solid-state relays & RCG-3

SDU Features

- Graphical & User-friendly
  - Design/operations team did not want crews to “fly the screen”
- Integrate all User I/O functions:
  - Speedometer
  - Current *and* Target Speed authority
  - Distance to go
  - Alarms & messages
  - Numerical keypad
- No signal *Aspects*
- Fit existing space in cab cars & MU’s

ICS Control/Display Unit Examples



What the “Speed Display Unit” shows

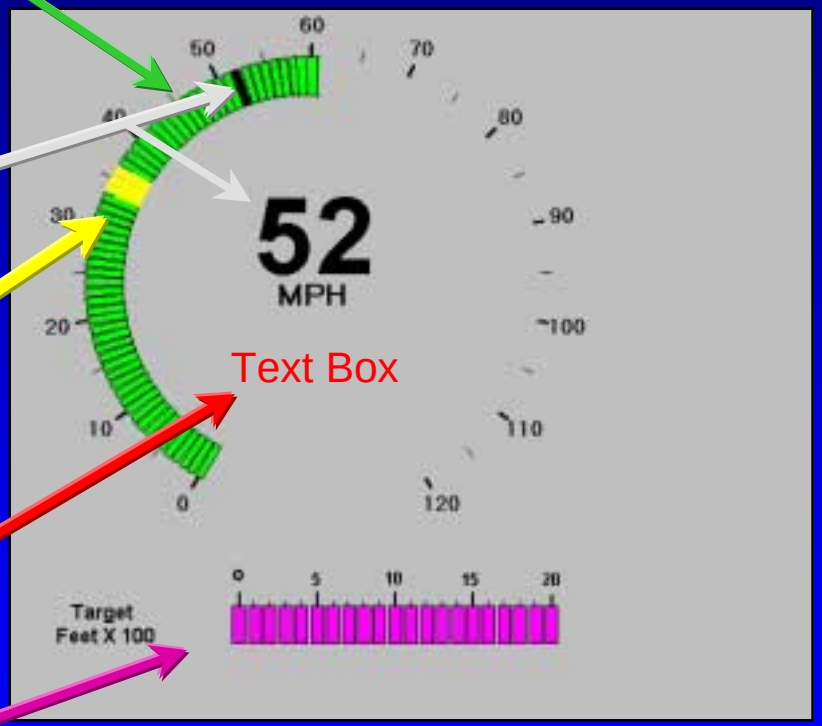
Green band shows maximum authorized speed

Black mark and numerals show current speed

Yellow band is target speed being approached

Red text box displays system messages

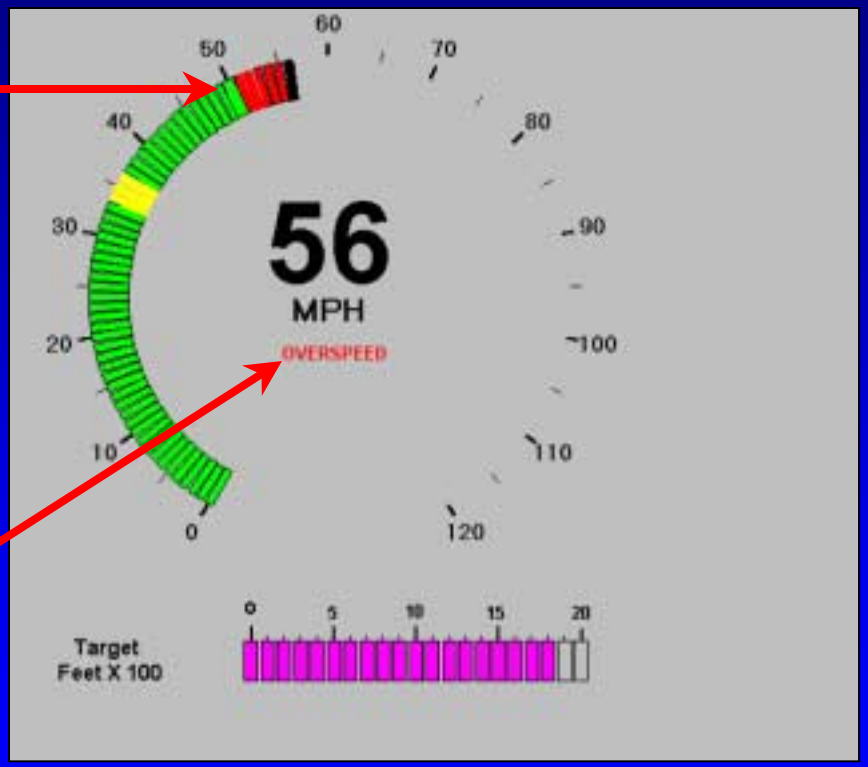
Magenta band shows distance to the target



March 2001

SDU Overspeed Display Approaching Target

- Speed band will turn red above the instantaneous authorized speed calculated from braking profile
- "Overspeed" text is displayed
- Sonalert sounds



Self-test features

- Transmission test
- CPS watchdog test
- Brake pressure input test
- Penalty brake test applies the penalty brake, and checks pressure reduction
- SDU alarm, display, and acknowledge test
- Code rate detection
- Overspeed detection


Questions?